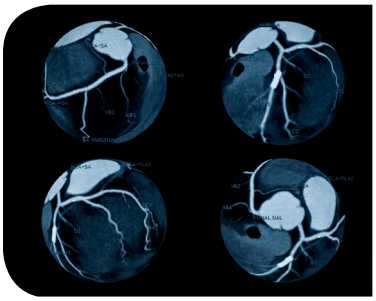

A PHYSICIAN'S GUIDE TO

Imaging Radiation Exposure

This care process model (CPM) was developed by Intermountain Healthcare's Cardiovascular Clinical Program and Imaging Clinical Service. It provides basic information on radiation used in imaging and recommends specific factors to consider when choosing an imaging strategy. It also describes steps Intermountain is taking to begin collecting each patient's cumulative radiation exposure from selected tests. This CPM was created as part of a multi-year (2011-2012) board goal; future documents will elaborate on this information and provide more detailed guidance. **Please note that while this document presents an evidence-based approach that is appropriate for most patients, it should be adapted to meet the needs of individual patients and situations,and should not replace clinical judgment.**

Key points

- **Imaging procedures that use ionizing radiation may pose a small increase in a patient's lifetime cancer risk.** Imaging procedures that use radiation are essential tools for medical diagnosis and treatment, and no published studies have conclusively linked cancer with radiation at the levels used in imaging. However, consensus statements from the American College of Radiology[1] and other clinical organizations suggest that it is reasonable to act on the assumption that low-level radiation may have a small risk of causing cancer. The general risk from the radiation in various imaging tests has been estimated, but the risk also depends on the patient's age, body size, and sex. For more details, see page 2.
- **Imaging tests and procedures vary in radiation exposure.** For example, when compared to a chest radiograph, a chest CT scan exposes a patient to approximately 70 times more radiation and a CT angiogram exposes the patient to approximately 160 times more radiation.[2] See page 2 for a comparison of common procedures.
- **The benefits of an indicated imaging procedure far outweigh the risks. However, healthcare providers should work together to decrease radiation exposure by:**
  - **Ensuring that an ordered procedure is necessary and appropriate.** The referring physician and radiologist play key roles in this process. See page 3 for guidance on evaluating whether to order an imaging test that uses radiation, with example situations when alternative imaging strategies may be preferable.
  - **Not repeating tests unnecessarily.** Checking the record for previous results (and asking the patient about results from other facilities) is an important, commonsense measure.
  - **Using radiation exposures that are as low as reasonably achievable for the images required.** See page 3 for information on how Intermountain's Imaging Service works to ensure radiation safety, including the use of ALARA (as low as reasonably achievable) dosing while ensuring quality images.
- **It's important to communicate with patients and families about the benefits and potential risks of a proposed procedure.** Patients may have questions (even if unstated) about imaging radiation, based on media coverage of this topic. For an indicated procedure, a clear and informative conversation can help patients understand the small risk and place it in context with the benefits of the procedure. See page 4 for guidance on talking with patients and links to patient education resources that can help in the conversation.

Why Focus ON IMAGING RADIATION?

- **Imaging radiation can pose a small increase in a patient's lifetime cancer risk.** See the first key point at left.
- **The use of imaging tests that rely on radiation — particularly CT scans — has grown dramatically.** Annual imaging radiation exposure in the US increased twenty-fold between 1980 and 2005[1]; up to 72 million CT scans are performed annually in the US (based on 2006 and 2007 data).[3]
- **The media has focused recently on the increase in imaging radiation and its risks.** Recent examples include coverage in *USA Today*, *Time*, *Newsweek*, the *New York Times*, and on MSNBC. This may prompt questions from your patients.
- **Intermountain Healthcare has set a goal to monitor imaging radiation exposure and educate providers and patients about it.** This CPM describes the efforts currently underway.

Goals OF THIS CPM

- Inform referring providers about ionizing radiation, relative estimated exposures and risks, and how age and sex affect risk.
- Provide brief guidance on factors that can inform the decision to order an imaging test.
- Help referring providers discuss imaging radiation with patients.
- Introduce Intermountain's efforts to measure imaging radiation exposures.

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MEASURING ESTIMATED RADIATION EXPOSURE

A patient's estimated radiation exposure (or "estimated effective dose") is measured in mSv units and is based on:

- The radiation energy used in the procedure
- The amount of radiation absorbed by the body part exposed
- The stochastic effects of the radiation (see below), averaged over the entire body

TERMS USED TO DESCRIBE RADIATION EFFECTS

Two terms are used when discussing the effects of ionizing radiation:

- **Deterministic effects:** Cell death at radiation exposures far higher than that used in most imaging studies. These effects are predictable, and can include permanent skin burns and hair loss.
- **Stochastic effects:** Genetic changes that may lead to the eventual development of cancer. These effects are probabilistic — they cannot be predicted accurately for an individual, and risk must be estimated.

OTHER FACTORS THAT AFFECT RISK

The cancer risk from an imaging radiation procedure also depends on:

- **The patient's sex.** The risk is considerably higher for women.[7]
- **The patient's body size.** The larger the patient, the more radiation is absorbed during a procedure; this can increase risk.

RADIATION BASICS

How is radiation measured? Many imaging procedures use **ionizing radiation** to provide detailed, useful information for diagnosis and guidance during interventions. Radiation exposure is measured in a variety of ways. The most useful measure for comparing the exposures in various procedures — also called the "effective dose" — is the **millisievert (mSv).** While body tissues have varying sensitivity to radiation exposure, this measurement refers to the radiation risk averaged over the entire body. See the sidebar for more information.

Natural sources: We are constantly exposed to ionizing radiation from natural sources; in the US, the average background radiation exposure is approximately 3 to 6 mSv per year.

How do procedures compare? The actual exposure from a procedure is based on equipment settings, body size, and other factors. All imaging tests are described as "low" radiation by international bodies that evaluate radiation exposure overall (see information on the BEIR VII report in the section below). However, it's helpful to know how procedures compare within this low level. The American College of Radiology[4] uses a comparative scale for average radiation levels, based on the uppermost settings seen in normal practice and an average-size adult patient. See the table below.

Relative Exposure	Common procedures
Minimal (under 0.1 mSv)	• **Radiograph:** Chest PA/LAT, extremity, bone densimetry
Low (0.1 – 1.0 mSv)	• **Radiograph:** Mammography, abdomen/pelvis
Moderate (1.0 – 10 mSv)	• **Radiograph:** Spine, IVP, upper GI or barium enema with fluoroscopy • **CT:** Head, chest (low dose), abdomen, pelvis, calcium scoring • **Interventional radiology:** Head/neck angiogram, coronary angiogram
High (10 – 100 mSv)	• **CT:** Chest (high resolution), coronary CT angiogram, virtual colonoscopy • **Interventional radiology:** Coronary angioplasty, stent placement, RF ablation, TIPPS

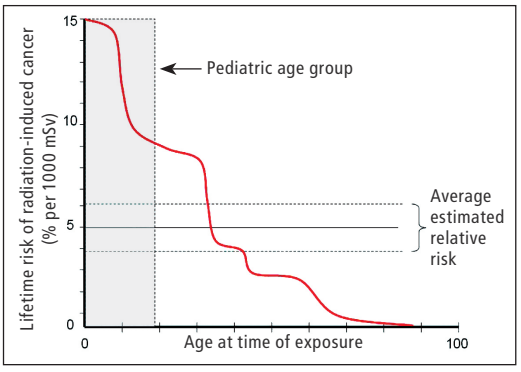
What is the risk?

No epidemiology studies directly link cancer to radiation at the levels used in imaging procedures. Cancer incidence is approximately 40% in the general population; the small added risk from low radiation exposures would be difficult to distinguish from the general risk. Instead, the cancer risk from imaging radiation is estimated using studies that document the increased cancer incidence in populations exposed to high radiation doses (above 500 mSv).

The 2006 report of the Biological Effects of Ionizing Radiation (the BEIR VII report)[5] estimated a lifetime risk of **1 cancer per 100 people with an exposure of 100 mSv.** While the radiation in an individual test is lower than this, the report concluded that cancer risk "proceeds in a linear fashion at lower doses without a threshold...the smallest dose has the potential to cause a small increased risk to humans." For estimated cancer risks associated with specific procedures using this method, see **www.radiologyinfo.org**.

How age affects risk

The cancer risk from imaging radiation depends on the patient's age at the time of exposure; the younger the patient, the higher the risk.[6] See the graph at right for estimated risks based on age. Extra caution is warranted when ordering imaging tests for pediatric patients, and unborn fetusus are at even greater risk — imaging radiation should be avoided if possible in pregnancy. By contrast, patients older than 65 have practically no added cancer risk.



Adapted from How to Understand and Communicate Radiation Risk,[4] ©2010 American College of Radiology

Cumulative exposure

Multiple imaging studies performed on the same patient may result in a cumulative radiation exposure of 100 mSv or more. Intermountain has set a multi-year goal to collect and report each patient's cumulative exposure from four procedures, if performed at Intermountain hospitals and clinics in 2012 or later: CT studies, angiography, nuclear cardiology, and cardiac cath. To generate a report for a patient in HELP2, open the patient's record and click the Radiation Exposure button in the main menu. As the report doesn't cover other tests or any procedures done at non-Intermountain facilities, it's important to ask patients about previous procedures involving radiation.

HEALTHCARE PROVIDERS PLAY A KEY ROLE

The sidebar at the right describes general ways that Intermountain works to ensure safety in imaging radiation. However, radiologists and referring physicians also play key roles in ensuring that imaging tests provide the greatest possible benefit to patients while minimizing any associated potential cancer risks. **The most important action you can take is making sure the test ordered is appropriate; consult a radiologist for guidance on imaging strategies if needed**.

The referring provider's role

Referring providers can minimize radiation exposure in three ways:

- **Choose imaging strategies wisely** by weighing the benefits against risks, evaluating patient characteristics and other factors (see guidance below)
- **Avoid unnecessary repetition** of imaging tests that use radiation
- **Educate the patient and family** about the risks and benefits of a procedure (see page 4).

Guidance for referring providers

The table below summarizes factors to consider when choosing an imaging strategy:

Factor	Notes
The need: Is the test necessary? Is the information already available?	• **Make sure the imaging information will affect diagnosis or treatment** and explain to your patient how you'll use the information. • **Avoid repeated tests if possible.** Ask the patient about previous test results; a test may have been performed elsewhere. Carefully weigh the utility and need for follow-up imaging.
The patient: What age is the patient? Is the patient pregnant?	• **Pediatric patients:** Children have a higher cancer risk from imaging radiation; consider alternative strategies. • **Pregnant patients:** Use alternative imaging strategies (such as ultrasound) if at all possible.
The procedure: Is it appropriate for the need?	• **Appropriate use criteria from the American College of Radiology are available online at www.acr.org/ac.** The criteria are easy to use and cover a wide range of imaging procedures. • **Appropriate use criteria from the American College of Cardiology are available at www.cardiosource.org/Science-And-Quality/Quality-Programs/Imaging-in-FOCUS/ACC-Appropriate-Use-Criteria.aspx.** • **Appropriate use guidelines** developed by Intermountain for selected cardiovascular procedures, based on the ACR and ACC criteria, are available at the Cardiovascular Clinical Program page on **intermountain.net**.
The accumulated exposure: How much imaging radiation has the patient already had?	**Ask patients about their previous procedures involving imaging radiation.** Future versions of this CPM will provide more information on how accumulated exposure can guide decisions, but it's a reasonable approach to show more caution with patients who have had a large number of CT scans or other higher-exposure procedures.

SAFE, HIGH-QUALITY IMAGING AT INTERMOUNTAIN

Intermountain participates in the Image Wisely and Image Gently campaigns. These campaigns (see page 4 for links) involve the following commitments:

- ALARA — using radiation exposures that are **a**s **l**ow **a**s **r**easonably **a**chievable for quality images.
- Pediatric adjustments — altering radiation exposures and processes for the needs of each child.
- Training technicians regularly in radiation safety.
- Evaluating and maintaining imaging equipment.

ULTRASOUND OR MRI AS ALTERNATIVES TO CT

See several examples below, and check the appropriate use criteria at left for more information.

- **Ultrasound[8]:** Pelvic pain in women, some types of abdominal pain, clinically suspected pelvic masses, imaging in pregnancy, and cardiovascular imaging in certain circumstances.
- **MRI[9]:** Pleural and chest wall soft tissues, abdominal and/or aorta angiography, pulmonary nodules (to 2-3mm), pediatric congenital heart disease, kidney masses, pelvic soft tissue disease, bowel inflammation, and multiple diseases of the liver, bile ducts/gall bladder, pancreas, adrenal glands, and peritoneum.

FULL-BODY CT SCANS

Advise patients to avoid full-body CT screening. Full-body CT screening for asymptomatic people, increasingly marketed to the public, has no scientific evidence that it provides more benefit than harm. The FDA and ACR do not recommend this practice.[10]

REFERENCES CITED IN THIS CPM

1. Amis ES Jr, Butler PF, Applegate KE, et al; American College of Radiaology. American College of Radiology white paper on radiation dose in medicine. *J Am Coll Radiol.* 2007;4(5):272–284.
2. American College of Radiology and Radiological Society of North America. Radiation exposure in x-ray and CT examinations. RadiologyInfo Web site. http://www.radiologyinfo.org/en/safety/index.cfm?pg=sfty_xray. Accessed September 7, 2011.
3. Furlow B. Radiation dose in computed tomography. *Radiol Technol.* 2010;81(5):437–450.
4. Peck DJ, Samei E. How to understand and communicate radiation risk. Imagewisely Web site. http://www.imagewisely.org/Imaging-Professionals/Medical-Physicists/Articles/How-to-Understand-and-Communicate-Radiation-Risk.aspx. Accessed September 7, 2011.
5. National Research Council. *Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2.* Washington, DC: The National Academies Press; 2006.
6. Brody AS, Frush DP, Huda W, Brent RL; American Academy of Pediatrics Section on Radiology. Radiation risk to children from computed tomography. *Pediatrics.* 2007; 120(3):677–682.
7. Einstein AJ, Henzlova MJ, Rajagopalan S. Estimating risk of cancer associated with radiation exposure from 64-slice computed tomography coronary angiography. *JAMA.* 2007;298(3):317–323.
8. Levine D. Use of ultrasound as an alternative to CT. Imagewisely Web site. http://www.imagewisely.org/Imaging-Professionals/Imaging-Physicians/Articles/Use-of-Ultrasound-as-an-Alternative-to-CT.aspx. Accessed September 7, 2011.
9. Martin DR. Diagnostic imaging of thoracic-abdominal-pelvic diseases: the role for MRI as a high diagnostic yield, safe and cost-effective alternative to CT. Imagewisely Web site. http://www.imagewisely.org/Imaging-Professionals/Imaging-Physicians/Articles/Diagnostic-Imaging-of-Thoracic-Abdominal-Pelvic-Diseases.aspx. Accessed September 7, 2011.
10. Berlin L. Potential legal ramifications of whole-body CT screening: taking a peek into Pandora's box. *Am J Roentgenol.* 2003;180(2):317–322.

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TALKING WITH PATIENTS ABOUT RADIATION

Talking with your patient about radiation exposure can be challenging, but is nonetheless important. If a proposed procedure is indicated for a patient, the key is helping the patient put the radiation exposure into perspective. You can compare the additional cancer risk from the radiation in an imaging procedure (a fraction of 1%) with the fact that every person has a 42% lifetime cancer risk.

The best approach tailors the conversation based on the exposure level from the proposed procedure. See the guidance below, based on the radiation exposure categories on page 2.

- **For a test with minimal or low radiation exposure:** Compare the radiation from the procedure to background radiation. For example, a chest radiograph involves the same exposure as spending about 10 days in one's natural surroundings. A mammogram involves the same exposure as about 7 weeks in natural surroundings.
- **For a procedure that involves moderate exposure:**
  - Explain that the procedure involves more radiation than a basic x-ray and may pose a slight increase in their lifetime cancer risk.
  - Use Intermountain's patient education materials (see information below) and refer patients to the RadiologyInfo website (see link below) to check the exposure for the proposed procedure.
  - Discuss the information you will gain from the procedure and how it will affect your diagnosis or treatment decisions.
- **For a procedure that involves high exposure:** In addition to following the tips for moderate exposure above, discuss the risks from NOT having the procedure.

KEY RESOURCES

For referring providers

- **Image wisely website.** Resources for referring providers. **www.imagewisely.org**
- **Image gently website.** Resources focused on pediatric imaging. **www.imagegently.org**
- **RadiologyInfo website.** Information from the ACR on radiation benefits/risks and radiation exposures in specific procedures. **www.radiologyinfo.org**
- **Appropriate use criteria.** See the description on page 3.
  - From the American College of Radiology (ACR): **www.acr.org/ac**
  - From the American College of Cardiology (ACC): **www.cardiosource.org/Science-And-Quality/Quality-Programs/Imaging-in-FOCUS/ACC-Appropriate-Use-Criteria.aspx.**
  - Intermountain's guidelines for appropriate use of CT pulmonary angiogram and nuclear stress tests, based on ACC criteria are on the Cardiovascular Clinical Program web page at **intermountain.net** or **intermountainphysician.org.**
  - Check your professional society's website; many societies include guidelines or criteria for imaging radiation.

For patients

- **Intermountain materials.** A brief brochure, a 2-page patient education fact sheet, and other resources are available on **intermountain.net** or **Intermountainphysician.org.** Copies can be ordered from **www.i-printstore.com.**
- **RadiologyInfo website (see link above).** Provides information on imaging procedures and lists estimated exposures for procedures that use radiation.
- **Image wisely and Image gently websites (see links above).** Provides education handouts, medical imaging record sheets, and other resources for patients.

Patient and Provider Publications 801.442.2963 CPM042 - 6/12